Status of anadromous Arctic charr (*Salvelinus alpinus*) of the Hornaday River, Northwest Territories, as assessed through harvest-based sampling of the subsistence fishery, August-September 1990-2007

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2009

Canadian Manuscript Report of Fisheries and Aquatic Sciences 2890

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2009

STATUS OF ANADROMOUS ARCTIC CHARR (*Salvelinus alpinus*) OF THE HORNADAY RIVER, NORTHWEST TERRITORIES, AS ASSESSED THROUGH HARVEST-BASED SAMPLING OF THE SUBSISTENCE FISHERY, AUGUST-SEPTEMBER 1990-2007

by

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Cat. No. Fs 97-4/2890E ISSN 0706-6473

Correct citation for this publication is:

Harwood, LA. 2009. Status of anadromous Arctic charr (*Salvelinus alpinus*) of the Hornaday River, Northwest Territories, as assessed through harvest-based sampling of the subsistence fishery, August-September 1990-2007. Can. Manuscr. Rep. Fish. Aquat. Sci. 2890: vii + 33 p.

DEDICATION

This report is dedicated to the memory of two past members of the Paulatuk Charr Working Group and the Fisheries Joint Management Committee. Their dedication and commitment to co-management in the Inuvialuit Settlement Region and the Hornaday River charr resource are greatly missed by all involved with this fishery.

Nelson Allen Green
1948-1999

Donovan H.F. Dowler
1926-2006

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ABSTRACT

Harwood, L. A. 2009. Status of anadromous Arctic charr (*Salvelinus alpinus*) of the Hornaday River, Northwest Territories, as assessed through harvest-based sampling of the subsistence fishery, August-September 1990-2007. Can. Manuscr. Rep. Fish. Aquat. Sci. 2890: vii + 33 p.

Anadromous Arctic charr (*Salvelinus alpinus*) spawn and over-winter in the Hornaday River. This stock has supported a subsistence fishery from 1940 to the present, a commercial fishery (1968-1986) and a sport fishery (1972-1978). A standardized long-term harvest-based monitoring program has been in place since 1990 with catch and biological data collected each year by community monitors. Trends in annual catch rate suggest the stock has been in decline since 2003 and has not fully recovered as of 2007. No statistically significant differences in mean catch rate or mean length were attributable to the various mesh sizes used in the fishery (114-166 mm stretch mesh). The sex ratio of the catch favoured males, but only slightly (average 1.1:1) with no obvious change over time. Age-frequency distributions revealed relatively stable age structure over the time series, except in 2007 when there was a shift to younger fish, but this may have been due to the small sample size that year. Modal age ranged from 6-9 years over the 18 years of the study with no obvious trend however, there was weak representation of the older age classes throughout. Finally, growth rates have been on the increase since 2002, which appear related to the timing (earlier) of break up of the land fast ice, and a concomitant increase in the quality and quantity of available prey for the char in the marine environment during summer.

Key words: subsistence fishery, Arctic char, growth, age, length, CPUE, reproduction, climate warming

RÉSUMÉ

Harwood, L. A. 2009. Status of anadromous Arctic charr (*Salvelinus alpinus*) of the Hornaday River, Northwest Territories, as assessed through harvest-based sampling of the subsistence fishery, August-September 1990-2007. Can. Manuscr. Rep. Fish. Aquat. Sci. 2890: vii + 33 p.

L'omble chevalier anadrome (*Salvelinus alpinus*) fraie et passe l'hiver dans la rivière Hornaday. Ce stock fait l'objet d'une pêche de subsistance depuis 1940, a fait l'objet d'une pêche commerciale (1968-1986) et d'une pêche récréative (1972-1978). Un programme normalisé de surveillance à long terme des captures est en place depuis 1990, des données de capture et des données biologiques sont recueillies chaque année par des surveillants des collectivités. Les tendances du taux de prises annuel semblent indiquer que la population est à la baisse depuis 2003 et qu'elle n'était pas entièrement rétablie en 2007. Aucune différence statistique notable du taux de capture moyen ou de la longueur moyenne n'était attribuable aux différentes tailles de mailles utilisées pour la pêche (maille extensible de 114 à 166 mm). Le rapport de chaque sexe dans les prises avantageait les mâles, mais à peine (moyenne de 1,1 pour 1), et aucun changement marqué n'a été noté avec le temps. Les distributions de fréquences des âges ont révélé une structure par âge plutôt stable pendant les séries chronologiques, sauf en 2007 où les poissons étaient plus jeunes, mais cette situation pourrait s'expliquer par la petite taille de l'échantillon cette année-là. L'âge modal variait de 6 à 9 ans pendant la période de 18 ans de l'étude, sans aucune tendance apparente. Toutefois, les classes plus âgées sont peu représentées tout au long de l'étude. Finalement, le taux de croissance est à la hausse depuis 2002 et semble lié à la période (hâtive) de débâcle de la banquise côtière et simultanément, à l'accroissement qualitatif et quantitatif des proies disponibles durant l'été pour l'omble dans l'environnement marin.

Mots-clés : pêche de subsistance, omble chevalier, croissance, âge, longueur, PUE, reproduction, réchauffement climatique

INTRODUCTION

The Hornaday River originates approximately 100 km due north of Dease Arm on Great Bear Lake, NT, and flows northwest for 280 km through the Melville Hills and into Darnley Bay (Fig. 1). Anadromous or sea run Arctic charr (*Salvelinus alpinus)* occur in the Hornaday River downstream of La Ronciere Falls (Reist et al. 1997) (Fig. 1) located 45 km from the mouth of the Hornaday River. Non-anadromous charr are also found in several lakes draining into the Hornaday mainstream, such as Seven Islands Lake and Rummy Lake (MacDonell 1996, 1997).

Charr that spawn and over winter in the Hornaday River system are assumed to comprise a discrete, geographically isolated stock (DFO 1999). Within the Hornaday River itself, there evidence that there may be two, perhaps three, origins of the charr found within the system. This is based on strontium levels in the primoridium of the otoliths from anadromous charr caught in the mainstream Hornaday River (Babaluk et al. 1998).

Searun Arctic charr spawn and over-winter in the river utilizing eight or more deep pools including the pool at the base of La Ronciere Falls (MacDonell 1996, 1997). Rearing areas used by the freshwater stages of the anadromous stock are not currently known. Age at first spawning, based on the youngest confirmed post-spawner caught to date, is thought to be seven years (Harwood 1999). In the Hornaday River, few charr are found that are older than 10 years of age.

During spring freshet (early June), the adult charr leave their over wintering areas and make their annual migration down the river and out into the coastal waters of the Amundsen Gulf (Fig. 1). The timing of spring break up in the river thus, the time when the charr have first access to their migration route to the ocean, has been monitored at a hydrometric water gauging station from 1999-2007 (L. Harwood, DFO, unpubl. data). The median date of the freshet during this time period was 11 June, ranging from 2-21 June (Fig. 2).

During the summer before spawning, not all over wintering fish make the spring migration to the ocean to feed. In such years, maturing individuals may remain in the freshwater riverine environment throughout the summer. Adult charr from the Hornaday appear to spawn every second year (Babaluk et al. 1998), although this is likely variable depending on the individual's fitness, environmental condition and possibly the age of the fish (Johnson 1980; Dutil 1984, 1986). After attaining a size of about 15-20 cm, the young pre-smolt charr begin their annual migration to the ocean in spring. The modal age of first time to sea appears to be three years, range from two to seven years (J. Babaluk, unpubl. data; n=20). Charr at the Hornaday appear to first go to sea and become sexually mature at younger ages than their counterparts to the east. For example, in the Holman area, charr from the Kuujjua River mature at 10 years (DFO, unpubl. data).

Residents of Paulatuk, a small traditional Inuvialuit community located 14 km west of the mouth of the Hornaday River, have harvested Arctic charr from this system since the community was first settled in the early 1940's and provides an important source of food for the growing population of Paulatuk. In 1968, a commercial fishery with an initial annual quota of 2,300 kg was established on the river. The quota was raised to 4,500 kg in 1974 and then to 6,800 kg in 1976 (Kristofferson et al. 1989). Although the commercial fishery produced fairly steadily at first, catches declined in the early 1980's leading to concerns about the state of the stock. In 1987, the commercial fishery was closed in response and has remained closed ever since with no plans to resume at this time.

In 1972, a small sport fishery was established on the Hornaday River by the Paulatuk Hunters and Trappers Committee (HTC) and this operated until 1978. At present, there is a limited sport fishery at the mouth of the Hornaday River during late summer, primarily by transient and permanent non-aboriginal residents of Paulatuk. The catch and possession limits for the Hornaday River sport fishery are some of the most restrictive in the NT, having been reduced to 1 and 1, respectively, in 1994/95. Within Tuktut Nogait National Park, sport fishing for charr is not allowed on the Hornaday or it tributaries.

A number of studies have been conducted on the charr of the Hornaday River. The commercial catches were sampled in 1973-1974, 1979, 1981 and 1983 (Kristofferson et. al., 1989) and test-netting was conducted in fall 1981 (Kristofferson et al. 1989). A full-span conduit weir was installed in August 1986 (MacDonell 1986) and again in August 1987 (MacDonell 1989). Although both weirs washed-out due to high water flows before the entire run could be enumerated, an extrapolation from the 1986 study was possible and produced an estimate of stock size of 16,000 charr. The weir data were recently re-examined and the estimate from that weir study revised to 15,000 (DFO 1999). Neither accounted for current year spawners in the estimate of the population size.

This subsistence monitoring program reported here is only one of several charr management initiatives underway by the harvesters of Paulatuk, NT. The objective of this program is to assess the status of the stock and to describe trends in the characteristics of the fishery over time. The study is expected to continue beyond the years reported here.

MATERIALS AND METHODS

Local fishers were trained and hired annually for 18 consecutive fishing seasons, from 1990 through 2007, to collect information on the catch-per-unit-effort (CPUE) of the fishery (1997-2007) and biological data (1990-2007) from the fish caught. The monitors were selected by the Paulatuk Hunters and Trappers Committee (HTC) and began work once families from Paulatuk moved to their seasonal fishing camps at the mouth of the Hornaday River, this usually in early-August. The monitors visited each fisherman's camp daily throughout the duration of the

fishery to interview and sub-sample the catch (n=8797 charr overall), using standardized forms and protocols.

Monitors kept records of total number of charr caught each day by fishermen and the length, mesh size, location, duration and number of nets used. They conducted 'full dead sample' analysis (length, weight, sex, maturity, stomach contents and aging structures) on a sub-sample of the overall catch, with a target of 300 charr per year. Ageing structures (sagittal otoliths) were placed in labeled scale envelope and age determinations were done by the same reader, according to Nordeng (1961). In addition to the dead samples described above, monitors collected additional length and weight information for a target sample size of 300 charr, also taken over the duration of the fishery each season.

DATA ANALYSIS

Statistical analyses were conducted using SAS version 8.0 on a PC (SAS 1990) following Sokal and Rohlf (1981). Catch-per-unit-effort (CPUE) was calculated as the number of Arctic charr per 100 m of net fished for 24 h. The number of sets for each of five different mesh sizes was tallied for 1997-2007 (Table 1). The daily catch record and mean annual CPUE were plotted for the period 1997-2007. A GLM (General Linear Model) in SAS V 8.2 (1996) was used to examine for statistical differences in the mean annual CPUE and mean length of Arctic charr harvested with the five different mesh sizes used in this fishery, and a Duncan's Multiple Range test to indicate specific differences among meshes and years. Mean weighted mesh size (weighted by net length and set time) was examined over the time series using GLM.

Age- and length-frequency distributions of the upstream migrants were constructed for charr caught in the fishery (1990-2007). A GLM and a Duncan's Multiple Range test used to examine for differences in the mean fork length and age of male and female charr caught and sampled over the course of the monitoring study. The modal age, sex ratio, and the percentage of Arctic charr in the sample >600 mm were tabulated.

Catch curves were constructed for each year of sampling by plotting the running average of three age frequencies against log age. Instantaneous mortality rate (Z) was then calculated using a least squares regression on the descending limb of the catch curve. Only age groups that were fully recruited into the catch were used following Ricker (1975). Annual survival rate (S) and annual mortality rates (A) were calculated based on Z (Ricker 1975).

Relative condition factor (K), a measure of the relative robustness of the fish, was determined by the following formula (Anderson and Gutreuter 1983):
$K = W \times 10^5/L^3$, where W = round weight in g, L = fork length in mm.

Mean annual somatic condition was compared to date of clearing of the sea ice in the Amundsen Gulf. The timing of break up and the length of the ice-free season in Eastern Amundsen Gulf were determined for each year using ice charts from the Canadian Ice Service (H. Melling, DFO, unpubl. data). For a given year, total ice-free days were summed from the first day of ice clearing (the earliest day showing a lead approximately 10 km wide near the mouth of Prince Albert Sound) to the first day of ice freeze-up (the first day showing a continuous cover of new ice that did not subsequently dissipate).

Mean fork length-at-age was calculated for each year class both for males and females and plotted to examine annual growth and variations in size-at-age between years and compared using GLM.

RESULTS AND DISCUSSION

THE FISHERY

The subsistence harvest of Arctic charr by residents of Paulatuk takes place primarily during late August, during the charr's upstream migration to over-wintering locations in the Hornaday River. An additional but smaller catch comes from the same stock during the downstream migration in spring, and from the under-ice fishery at the over-wintering pools in October and November. However, the spring and fall fisheries are included in the regular monitoring program and are not reported here.

Mono-filament gillnets, 30-50 m in length and meshes ranging from 114-166 mm are used in the late summer fishery (Table 1). A total of 85% of the charr dead sampled during the course of this program were caught using the 114 mm (4.5") and 127 mm (5") mesh nets. Forty-four different fishers were involved in the late August subsistence fishery between 1997 and 2007, averaging 12 per year (range 6-16 per year).

The duration of the summer fishery was relatively consistent over time, averaging 21 d (range 9-25 d) each year from 1990-2007 (Fig. 3). Within the monitoring series, the peak of the fishery was earliest in 1998 (July 27) and latest in 2007 (September 3). All years in the series, except 1993, 1998, 1999, and 2007, peaked within 5 d of the median date of August 14 (Fig. 4).

Catch-Per-Unit-Effort (CPUE)

Catch-per-unit-effort (CPUE) can indicate changes in stock size but can be affected by changes in the magnitude of recruitment, timing of migrations, local environmental conditions and/or changes in fishing methods/locations. The plot of mean mesh size weighted by fishing effort (net length x hr) showed a slight (<20

mm increase) but insignificant, trend toward use of increasing mesh sizes over time (Fig. 5).

The Duncan's Multiple Range test indicated that there were no statistically significant differences ($p>0.05$) in mean CPUE using any of the mesh sizes (114 mm, 127 mm, 133 mm, 140 mm, 166 mm ($F=20.24$, $df=4$, 3388; $p>F<0.0001$; Duncan's groupings: $p>0.05$ in CPUE for 102 mm, 114 mm, 127 mm mesh). CPUE for mesh 114 mm had the highest value in the series (24.55), and CPUE for the other meshes were all within the range from 16.1-18.4. In addition, differences in the size of fish caught with the different mesh sizes used in the fishery were not statistically significant ($F=81.58$, $df=2$, 1991; $p>F<0.0001$; Table 1).

Between 1997 and 2007, overall mean CPUE for the fishery was 19.25 charr/100 m/24 h (sd=8.9, range=5.01-33.08 charr/100 m/24 h). The highest observed CPUE was 2003, after which time CPUE decreased each year through 2007 inclusive ($R^2=0.3235$, Fig. 6). Annual harvests during the late summer fishery from 1997-2007 averaged 772 charr (sd=388.7, range=121-1311), and followed a similar decreasing trend over time ($R^2=0.7468$).

Individual CPUE records were collected from 44 different fishers from 1997-2007. Of these, four fishers had records for eight or more years in the monitoring period. Fluctuations in CPUE for these four fishers (Fig. 7) were similar to each other and followed the same patterns as overall CPUE. Together these data suggest a decline in the stock from 2003 onward, and one which had not recovered by 2007.

BIOLOGICAL ASSESSMENT

LENGTH, WEIGHT AND CONDITION

The largest charr caught in this fishery was caught in 2000, weighing 9150 g and 833 mm in length. Length frequency distributions for all Arctic charr sampled from this fishery are shown in Fig. 8. Sample sizes of dead sampled charr were low in both 2006 (n=53) and 2007 (n=36). The annual mean (+sd) fork length of the harvested charr are shown on Fig. 9. The percent of charr >600 mm averaged 32.3% (sd=11.1, range=16.4-54.7%) between 1990-2007 (Table 2).

Mean fork lengths for males were greater than for females ($F=50.66$, $df=1$, 3535, $p<0.0001$; $X=583.4$ mm for males, n=1880; $X=566.4$ mm for females, n=1657) when compared overall, and when compared separately for meshes 114 mm (n=1503, $p<0.05$), 127 mm (n=1126, $p<0.05$) and 140 mm (n=418, $p<0.05$) (Fig. 10).

Comparing the mean fork length of charr caught in this fishery over time, male charr ($F=7.14$, $df=17, 1862$; $p<0.0001$) and female charr ($F=8.25$, $df=17, 1639$, $p<0.0001$) were in the same Duncan grouping and had greater mean fork lengths in each of 2002-2006 than in all other (previous) years of the monitoring study.

The average weight of charr caught in this fishery increased through 2006 (Table 2). The somatic condition of charr caught in the upstream migration fishery averaged K=1.24 (sd=0.07, range=1.15 in 1997 to the highest value of K=1.37 in 1998, 1.38 in 1999). Differences among years are thought to reflect differences in quality or quantity of food available to the charr during the important summer feeding period (Dutil 1984). Years of highest somatic condition in the charr were correlated with years of early break up of the land fast ice in the near shore Beaufort Sea. Somatic condition index (K) and date of ice clearing are plotted on Fig. 11, depicting a strong relationship between an earlier timing of break up and increased K ($R^2=0.5239$).

SEX RATIO, MATURITY AND SPAWNING

The sex ratio of the catch averaged 52.9% males (sd=7%, range=38-64%) but there were no obvious temporal trends toward one sex being favoured over another (Table 2). Less than 1% of the charr caught in the 1990-2007 fisheries were current-year spawners. Usually less than five are caught per year and often none are reported. In 1998, the number of current-year spawners that were caught was higher (n=19), although this still represented only a small portion of the catch (1.5%).

AGE AND MORTALITY

A sub-sample of 3,289 charr was aged for this study (Table 2). The youngest fish caught in this fishery was 2 years (n=2), while the oldest was 13 years (n=8). Charr are recruited to this fishery at age 5 years, while the age at first trip to sea appears to be 3 years (Babaluk et al. 1998). Few of the charr caught in the fishery (e.g. 5.4%) are aged 10 years or older, with the majority (75%) being aged 5-7 years.

The mean age of charr caught in this fishery was 7.2 years (Fig. 12), ranging from 6.2-7.9 years. Fluctuations in mean age likely reflect younger fish becoming increasingly vulnerable to the fishery either due to increased body size following a particularly favourable productive feeding season or, when the timing of the fishery differs from other years in the series (e.g. 2007).

The age-frequency distributions are also instructive and showed no clear shift in either direction of the age structure of the catch over time (Fig. 13). There was weak representation of the older age classes throughout all years of the study. The modal age remained at 7 or 8 years throughout the study, with the exception of a shift downward in 2007 likely attributable to the small sample size/late date of the fishery.

Instantaneous mortalities (Z) calculated from the catch curves for 1990-2007 (Table 3) varied from a low of 0.43 in 2007 to a high of 1.22 in 1993 (Fig. 14).

GROWTH

Mean length-at-age for the monitoring period (Fig. 15) increased over time. Although there was considerable variation in the length-at-age for charr from the upstream fishery, which is characteristic of this species (Johnson 1991), and typical throughout all years and size classes of this fishery (DFO 1999), the trend toward increased length-at-age was obvious for all ages represented in the fishery (5-9 years) and each was statistically significant ($p<0.05$). An examination of mean length-at-age separately for males and females revealed the same trend.

A possible explanation for the apparent increase in size of fish in the fishery in recent years is the effect of changing gear. However, our earlier analysis of mesh size effects did not show this to be the case. Since the increase in annual growth was similar across all sizes, with all size classes growing at a similar rate, this suggests that the effect was not density dependent, but rather an environmental effect.

The apparent increase in growth rates is unlikely due to a density dependent effect. Arctic charr feed little or not at all during migrations or while in freshwater over-wintering areas; they feed primarily in the ocean during the summer (DFO 1999). It is probable that food availability in the ocean is not a limiting factor, in fact, it is likely increasing through enhanced pelagic productivity due to climate warming (Walsh 2008).

With a trend toward earlier break up of the land fast ice in the Beaufort Sea (Fig. 16), oceanographic conditions which favor enhanced growth production of zooplankton are established earlier in the season than was the case a decade ago (Reist et al. 2006; Walsh 2008). Access to enhanced resources is a plausible explanation for the apparent increase in growth rates of Arctic charr observed during the past decade. This was also the case in other *Salvelinus* stocks in this region monitored with similar harvest-based programs over the same time period (e.g. Rat River, Harwood et al. 2009; Kuujjua River charr, DFO, unpubl. data).

SUMMARY AND CONCLUSIONS

Annual changes in the biological parameters and the success of the fishery, monitored over an extended period of time, provide a means by which to assess the status of a stock and the sustainability of the fishery. This monitoring program is only one of several Arctic charr management initiatives underway by

the harvesters of the Inuvialuit Settlement Region, working with the Fisheries Joint Management Committee (FJMC www.fjmc.ca) and Canada's Dept. of Fisheries and Oceans.

- There were no statistically significant differences in mean CPUE or mean length of the fish caught that were attributable to the different mesh sizes used in this fishery,
- CPUE indicates the size of the anadromous stock of Arctic charr available to the fishery declined after 2003 and had not recovered by 2007,
- With the exception of 2007, there has been a trend toward (1) increasing mean length of Arctic charr, and (2) increasing length-at-age for charr caught in this fishery,
- Age-frequency distributions, modal age (6-9 y), and sex ratio showed no clear shift in either direction of the age structure of the catch over time, with the exception of 2007, and there was weak representation of older age classes in all years of the study,
- The overall increase in growth rates may be related to the timing of break up of the sea ice, at least in part, which enhances feeding opportunities for Arctic charr,
- Increased growth of individuals in the stock provides increased biomass to the fishery and may help to offset the pressures of the harvest.

ACKNOWLEDGEMENTS

The work and dedication of the fishery monitors, Adam Ruben, Noel Green, Judy Green, Charlie Ruben, the late Nelson Green, Joseph Illasiak Jr., John Max Kudlak, Bobby Ruben, Ruben Ruben, Ian Green and Hank Wolki are gratefully acknowledged. My apologies to anyone that has been inadvertently missed. Peter Green and Ray Ruben, both of the Paulatuk HTC, assisted with program administration. The data could not have been collected without the support of the Paulatuk HTC and the people of Paulatuk, who allowed their catches to be enumerated and sampled. Special recognition goes to the late Nelson Green of Paulatuk, for his dedication to this program and indeed all of the charr management initiatives in the Paulatuk area. Ice data were tabulated and analysed by Dr. Humfrey Melling, Institute of Ocean Sciences, Sidney BC, and water gauge data were collected by G. Lennie, R. Pilling and R. Hanna of the Water Survey of Canada. The charr were aged by G. Carder, formerly of DFO, and presently of Salmon Arm, BC. Earlier programs were co-ordinated by D.V. Gillman (1988) and P.J. Lemieux (1989-1991), and most recently by K. Bill and E. Hiebert (2007), all of DFO. C. Read and C. Day, DFO, assisted with data analysis. Finally, A.

Kristofferson (DFO) and the late Don Dowler (Vice-Chair, Fisheries Joint Management Committee, FJMC), gave advice and support over the years it took to collect these data, and Steve Sandstrom (Ontario Ministry of Natural Resources) and Kelly Withers (DFO) provided helpful reviews of the manuscript. The FJMC is gratefully acknowledged for providing annual funding to conduct of the field work.

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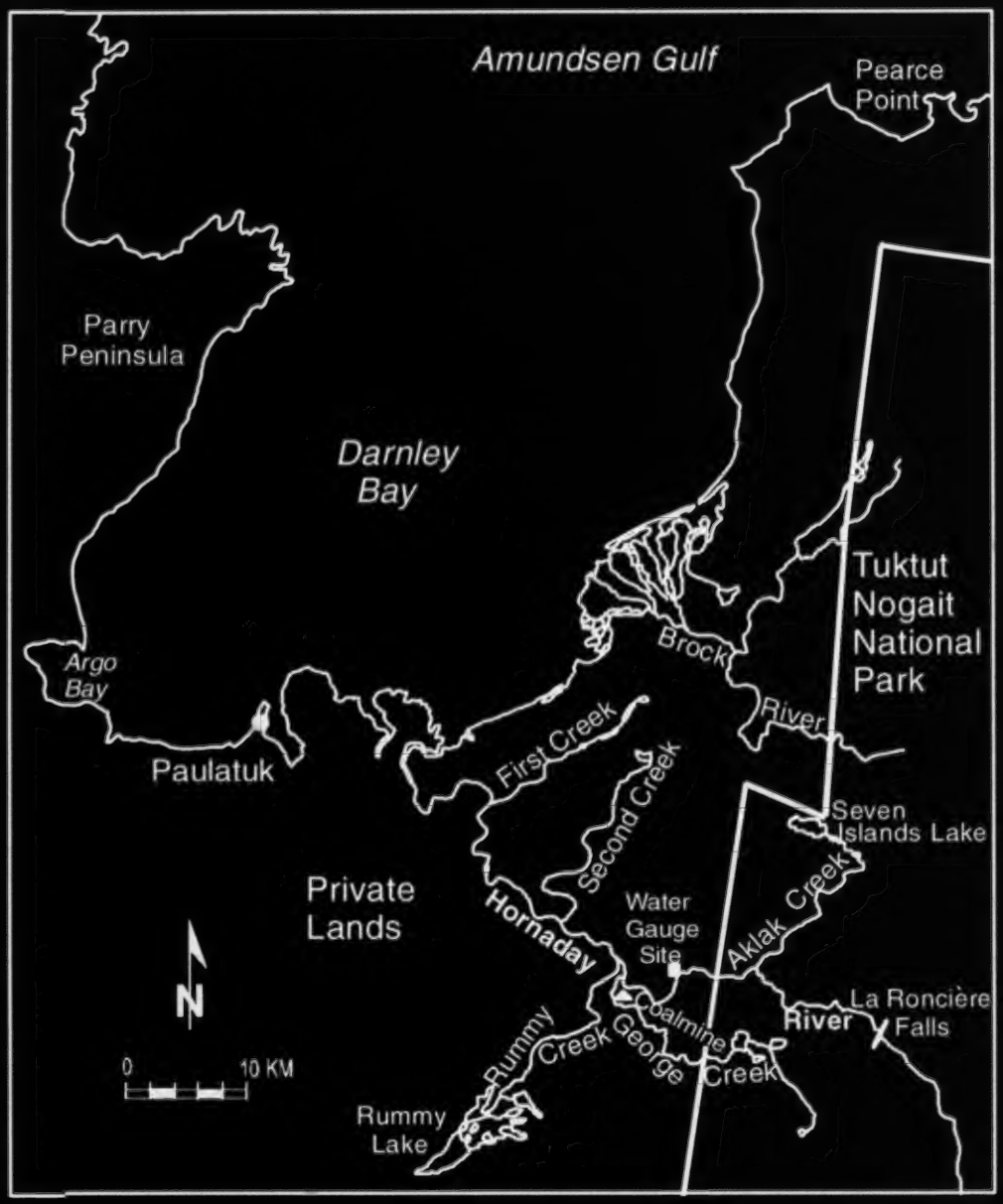


Fig. 1. The lower Hornaday River, and range of anadromous Arctic charr of the Hornaday River, NT, Canada.

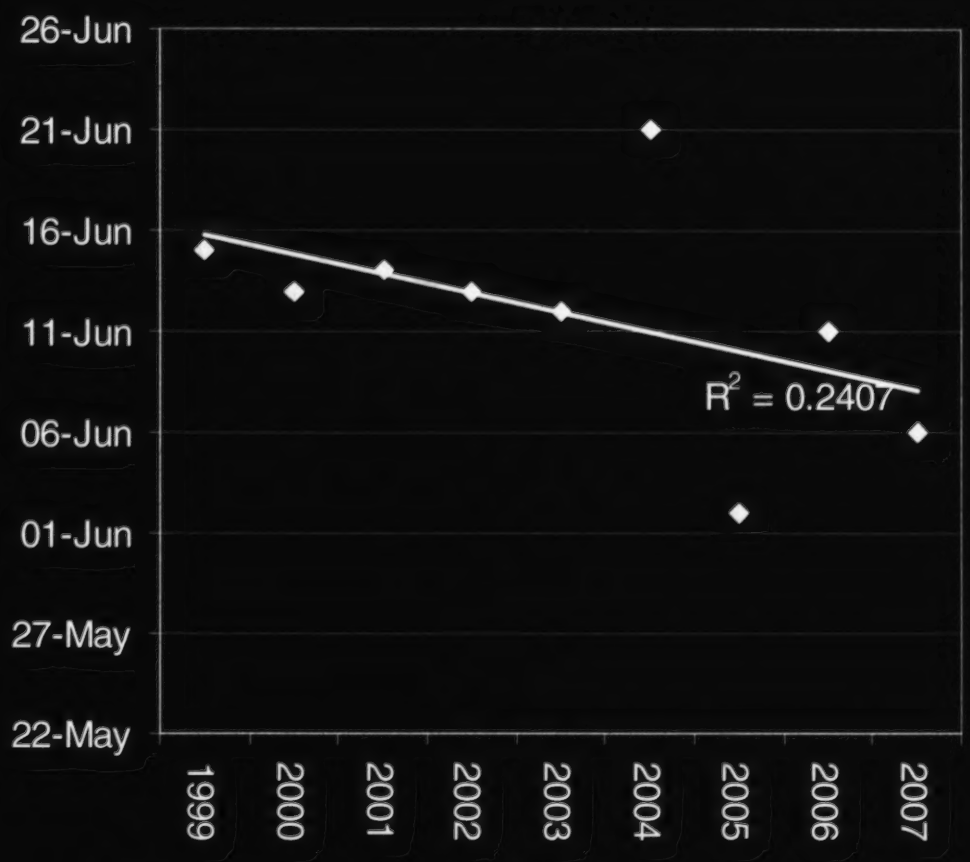


Fig. 2. Peak flows (freshet) at the Hornaday River during spring break up, 1999-2007 (DFO, unpubl. data).

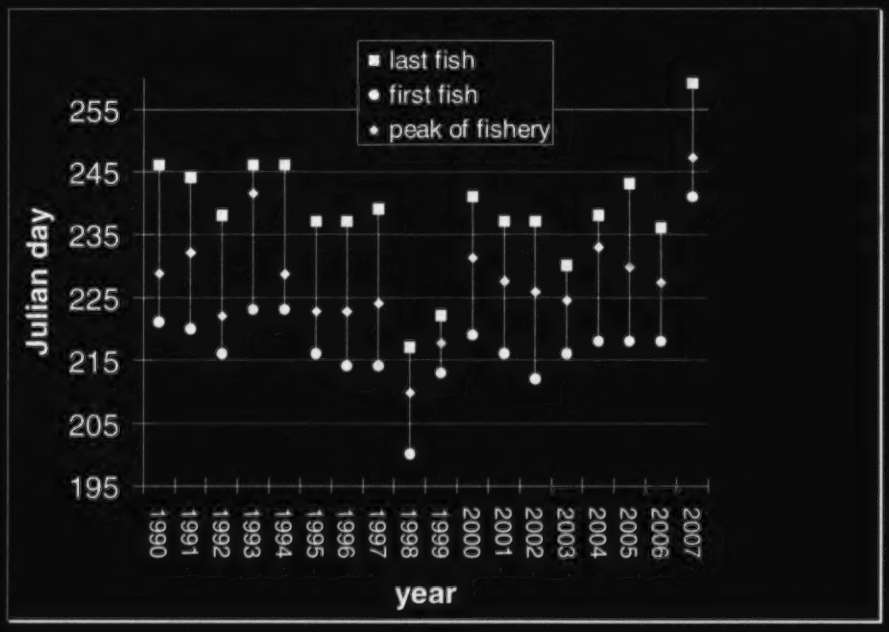


Fig. 3. Start, end and peak catch data of the Hornaday River Arctic charr subsistence fishery, 1990-2007.

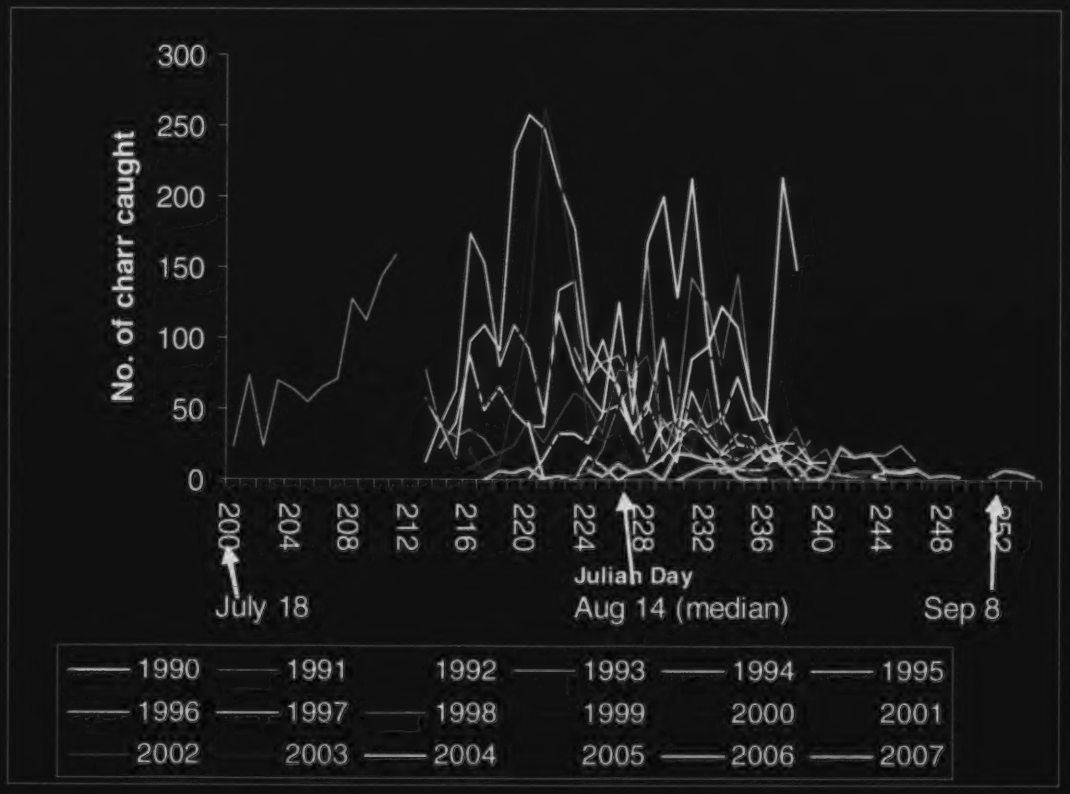


Fig. 4. Daily catch of Arctic charr from the subsistence fishery at the Hornaday River, 1990-2007.

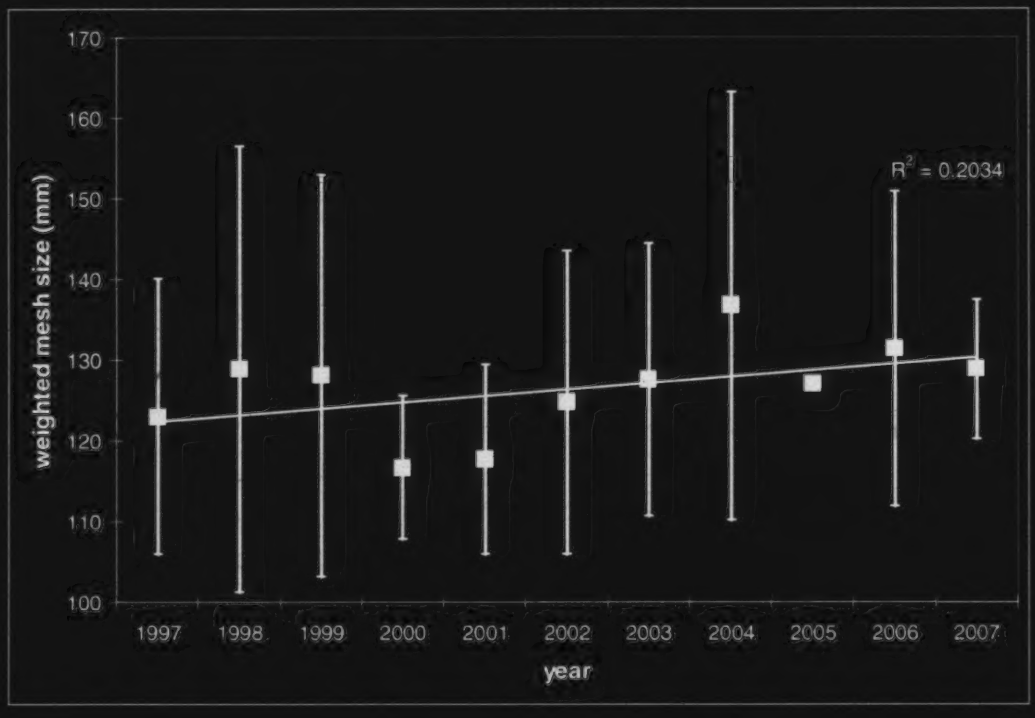


Fig. 5. Annual mean effort weighted mesh size (+1 sd) for the Hornaday River Arctic charr subsistence fishery, 1997-2007.

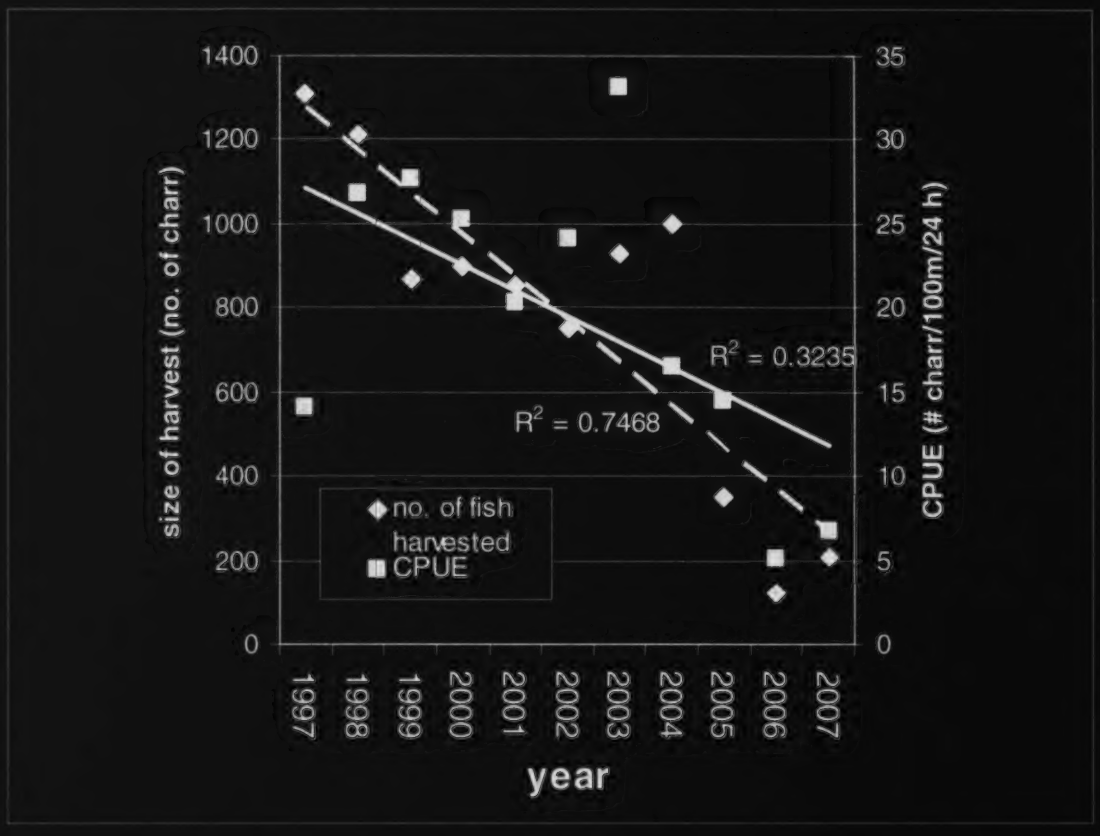


Fig. 6. Mean annual CPUE and total catch for the late summer Hornaday River subsistence fishery, 1997-2007.

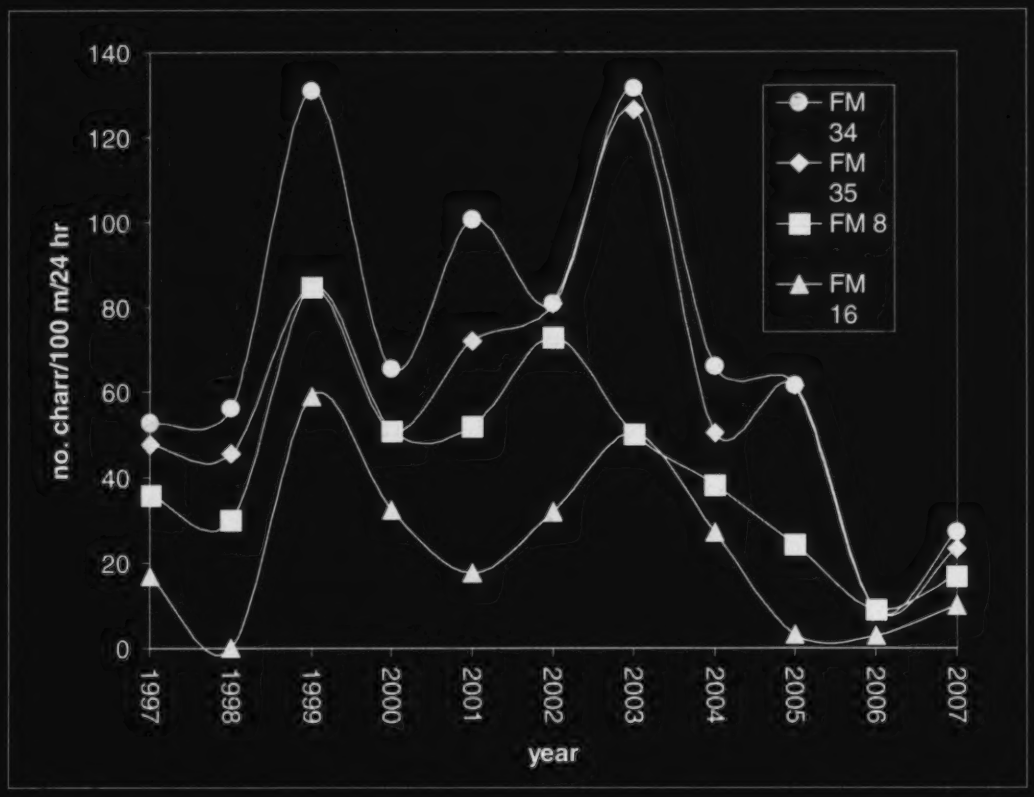


Fig. 7. CPUE for four individual fishers at the Hornaday River subsistence fishery, 1997-2007.

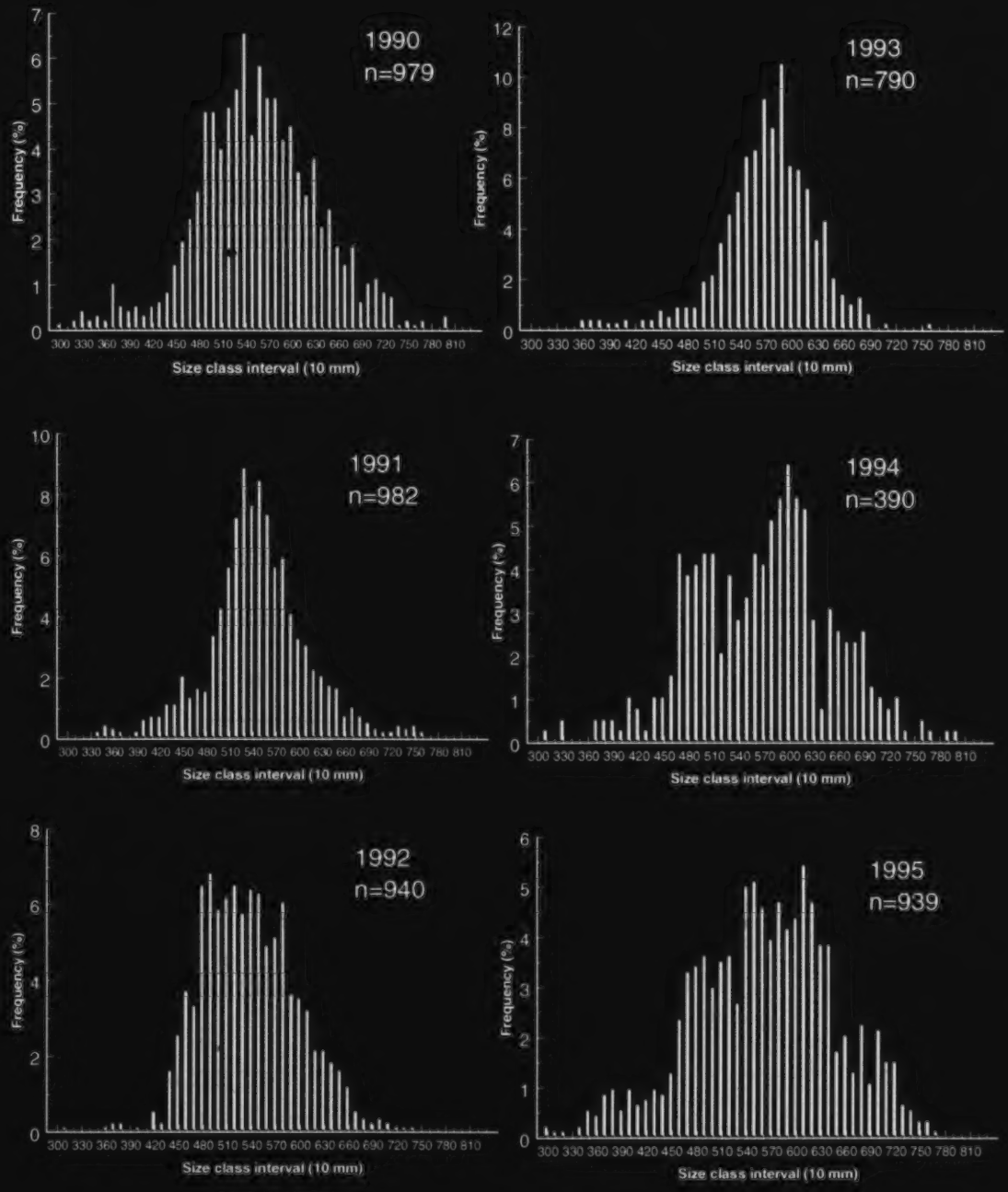
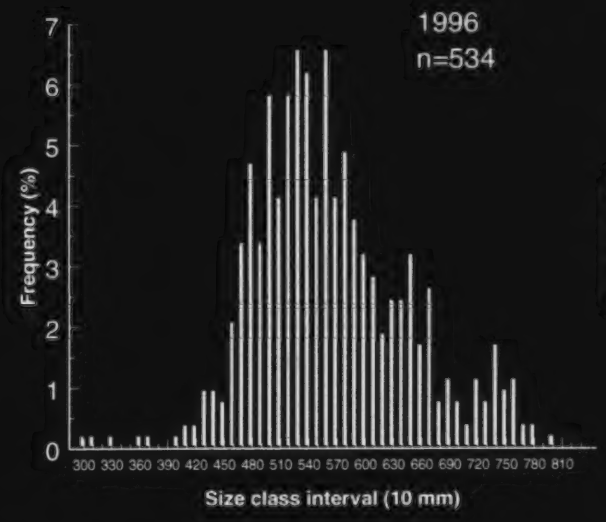
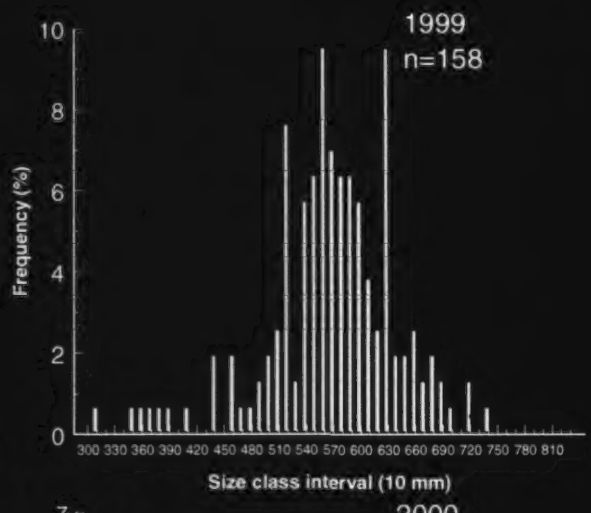
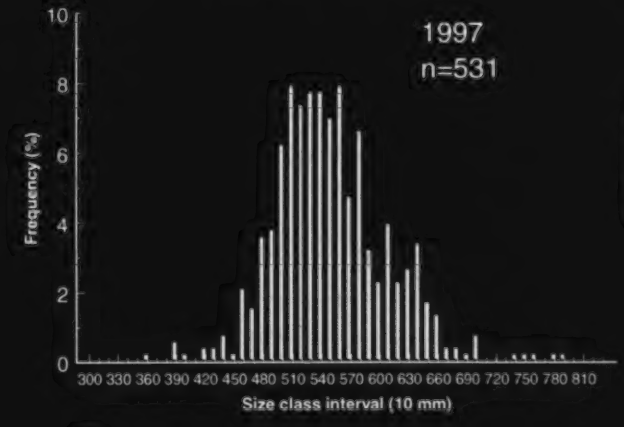
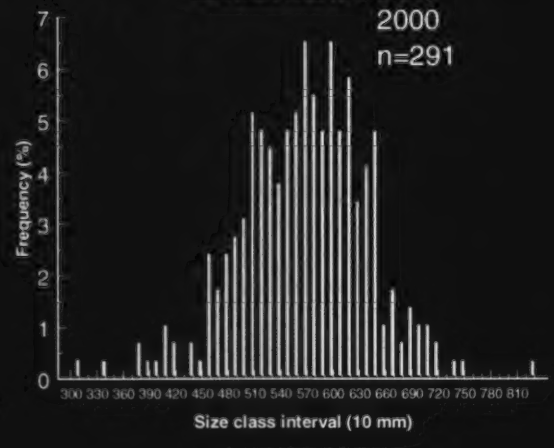


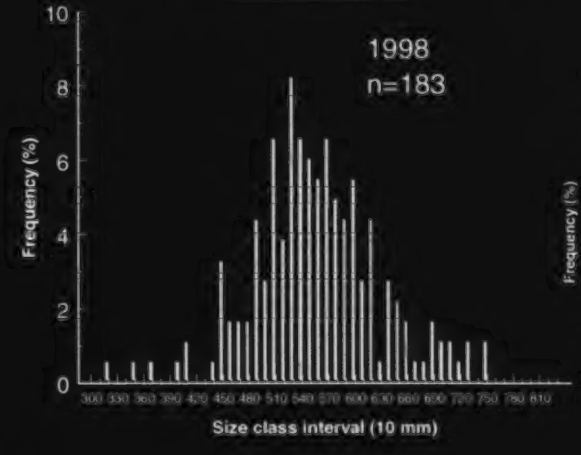
Fig. 8. Length frequency distribution of Arctic charr sampled at the Hornaday River subsistence fishery, 1990-2007.


1996
n=534
Frequency (%)
0 1 2 3 4 5 6 7
300 330 360 390 420 450 480 510 540 570 600 630 660 690 720 750 780 810
Size class interval (10 mm)


1999
n=158
Frequency (%)
0 2 4 6 8 10
300 330 360 390 420 450 480 510 540 570 600 630 660 690 720 750 780 810
Size class interval (10 mm)


1997
n=531
Frequency (%)
0 2 4 6 8 10
300 330 360 390 420 450 480 510 540 570 600 630 660 690 720 750 780 810
Size class interval (10 mm)


2000
n=291
Frequency (%)
0 1 2 3 4 5 6 7
300 330 360 390 420 450 480 510 540 570 600 630 660 690 720 750 780 810
Size class interval (10 mm)


1998
n=183
Frequency (%)
0 2 4 6 8 10
300 330 360 390 420 450 480 510 540 570 600 630 660 690 720 750 780 810
Size class interval (10 mm)

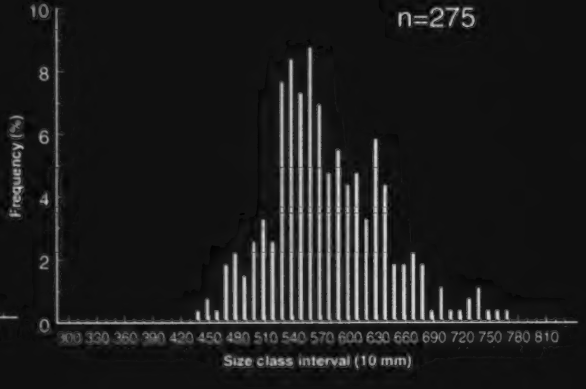

2001
n=275
Frequency (%)
0 2 4 6 8 10
300 330 360 390 420 450 480 510 540 570 600 630 660 690 720 750 780 810
Size class interval (10 mm)

Fig. 8. Cont'd.

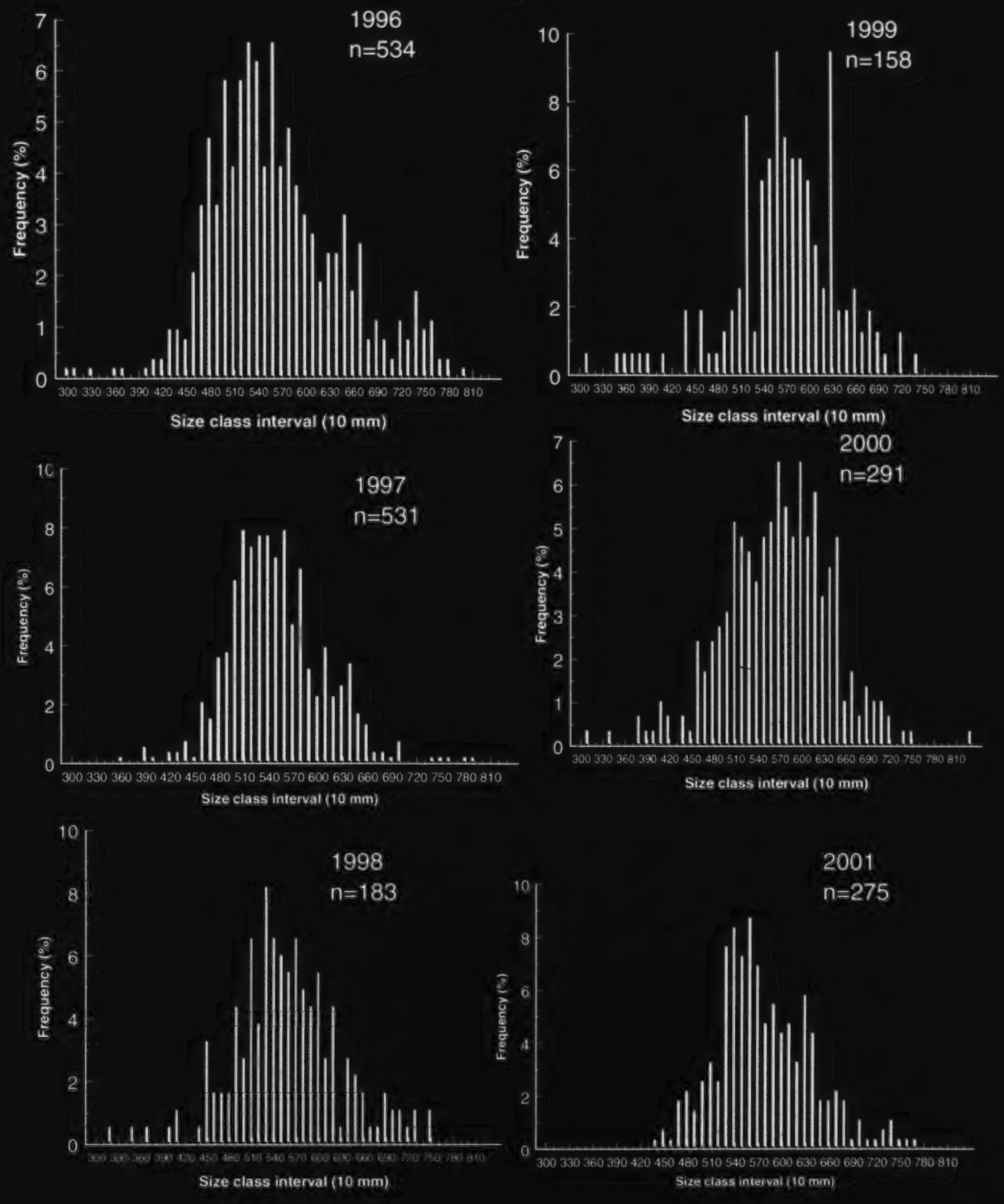

1996
n=534
1999
n=158
1997
n=531
2000
n=291
1998
n=183
2001
n=275
Frequency (%)
Size class interval (10 mm)
300 330 360 390 420 450 480 510 540 570 600 630 660 690 720 750 780 810

Fig. 8. Cont'd.

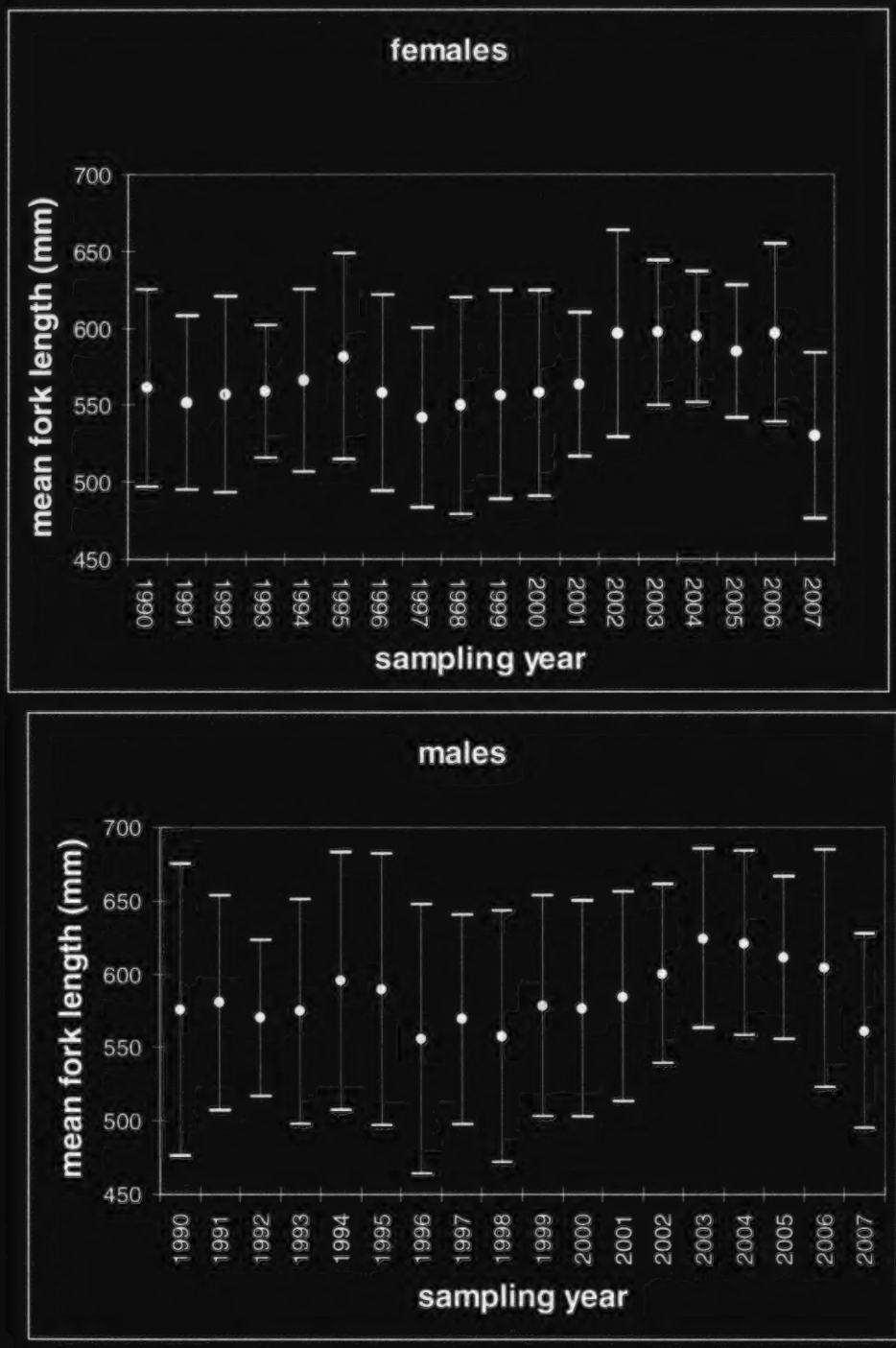


Fig. 9. Mean fork length of female and male Arctic charr taken in the subsistence fishery at the Hornaday River, 1990-2007 (n=3428).

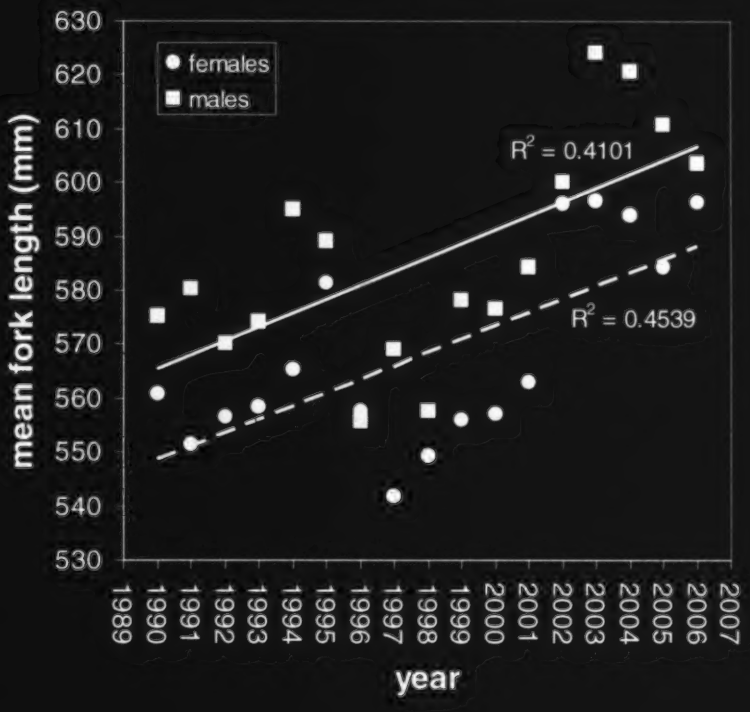


Fig. 10. Trend in mean fork length in male and female fork length of female and male Arctic charr taken in the subsistence fishery at the Hornaday River, 1990-2006 (n=3428).

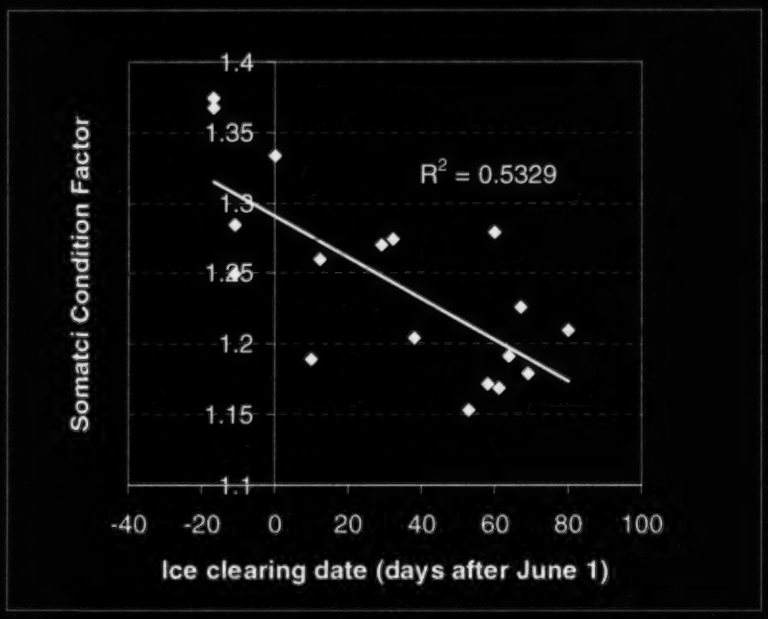


Fig. 11. Date of clearing of the land fast ice in Eastern Amundsen Gulf vs body condition of Arctic charr caught in the Hornaday River subsistence fishery, 1990-2007.

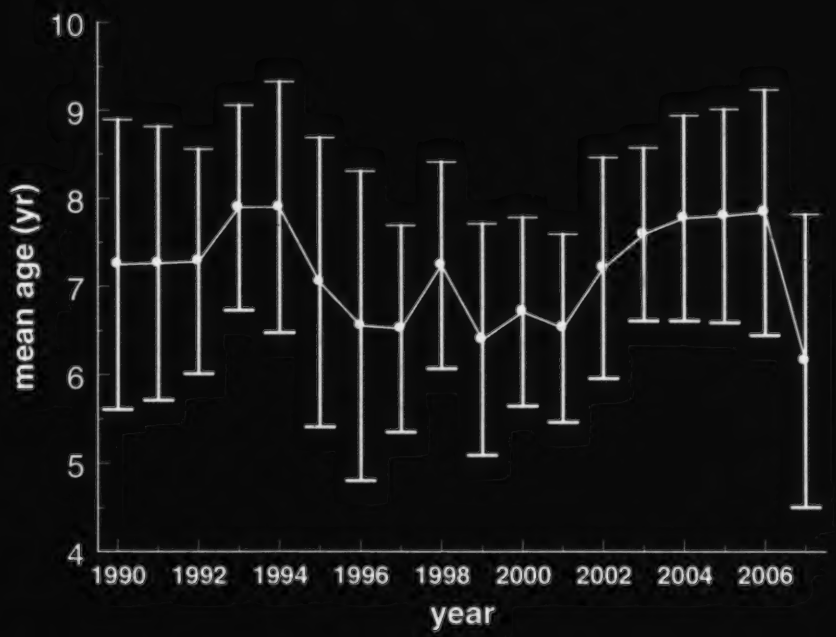


Fig. 12. Mean age of Arctic charr sampled in the subsistence fishery, Hornaday River, 1990-2007 (n=3478).

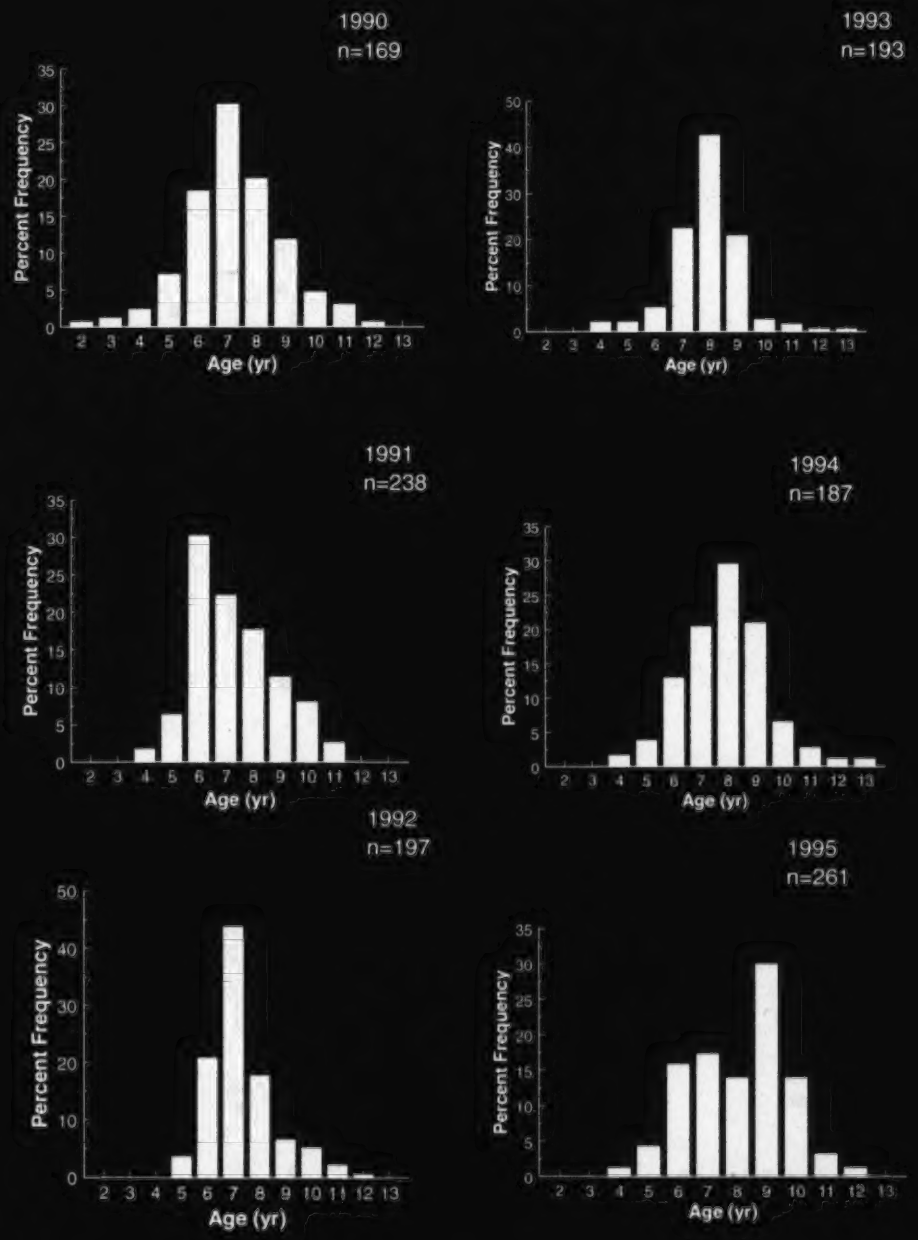


Fig. 13. Age frequency distribution of Arctic charr sampled at the Hornaday River subsistence fishery, 1990-2007.

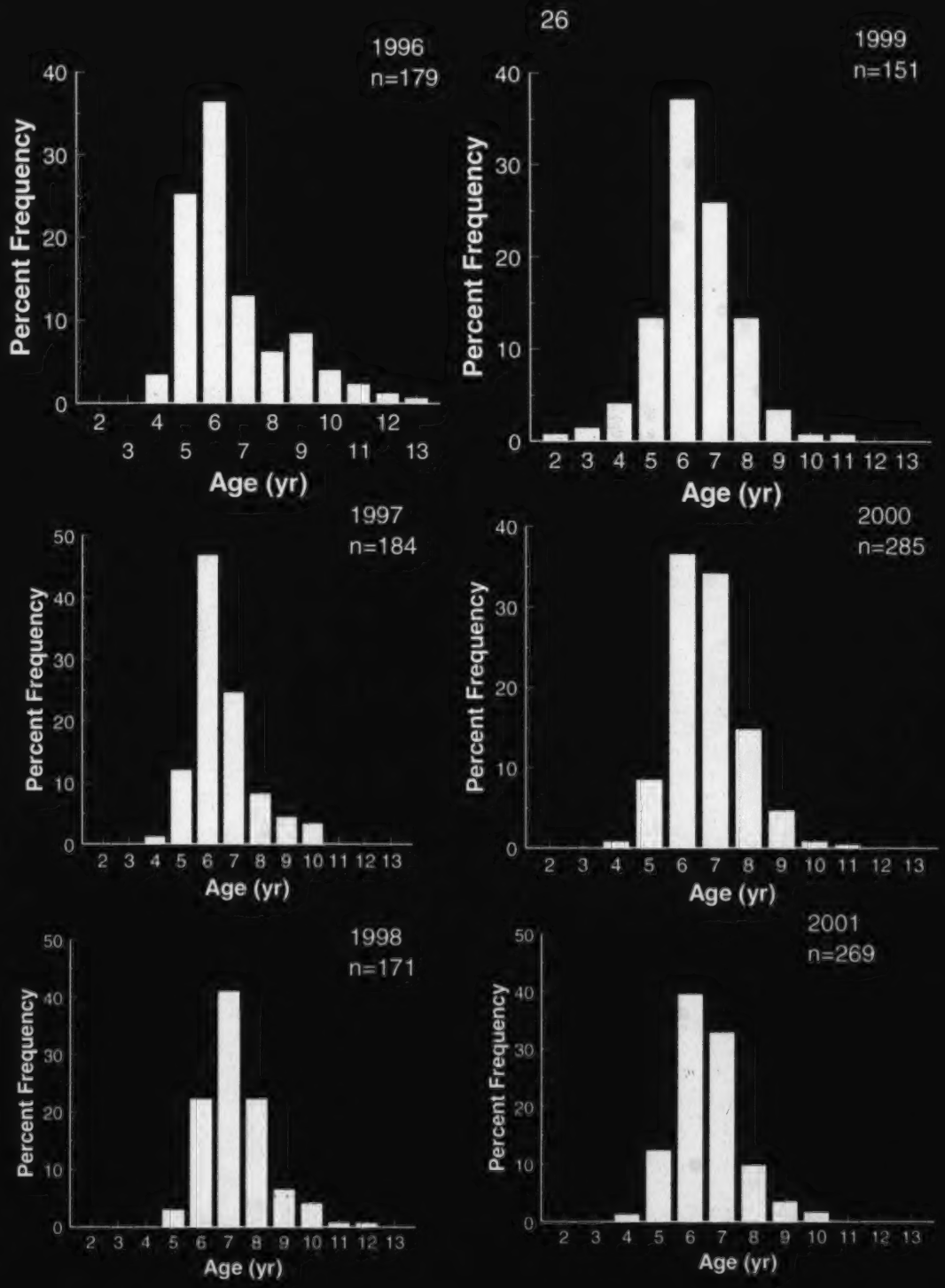
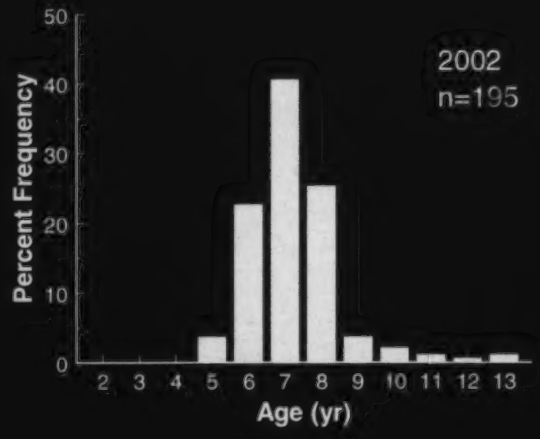
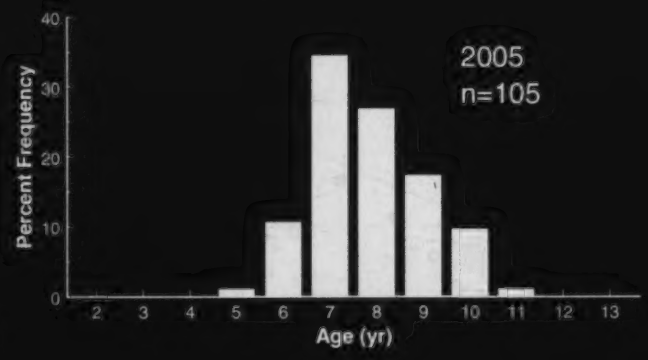
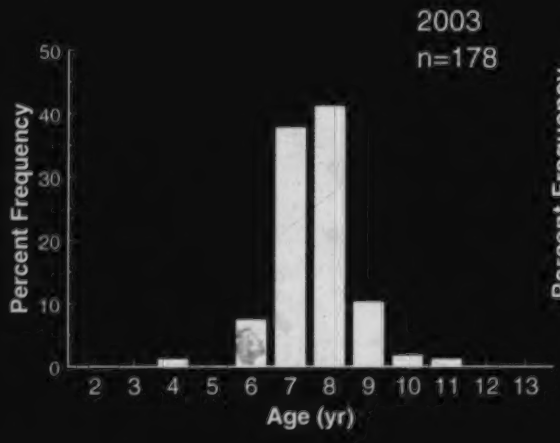
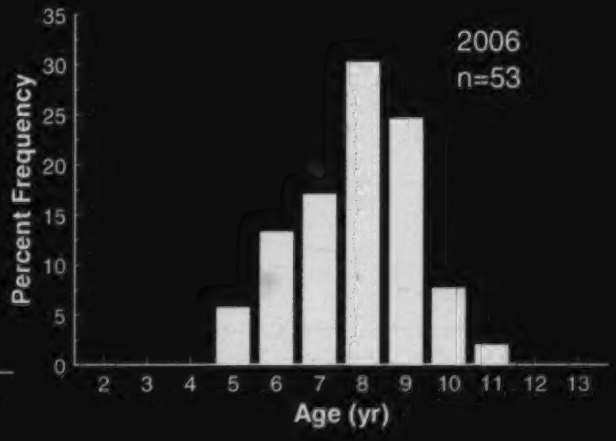

1996
n=179
1999
n=151
1997
n=184
2000
n=285
1998
n=171
2001
n=269
Percent Frequency
Age (yr)

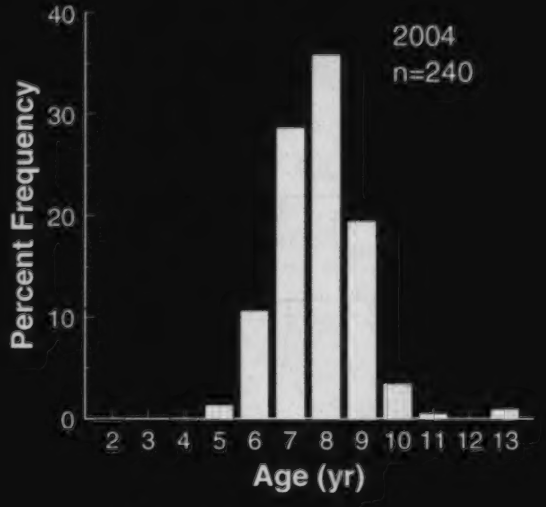
Fig. 13. Cont'd.


2002
n=195
Percent Frequency
Age (yr)


2005
n=105
Percent Frequency
Age (yr)


2003
n=178
Percent Frequency
Age (yr)


2006
n=53
Percent Frequency
Age (yr)


2004
n=240
Percent Frequency
Age (yr)

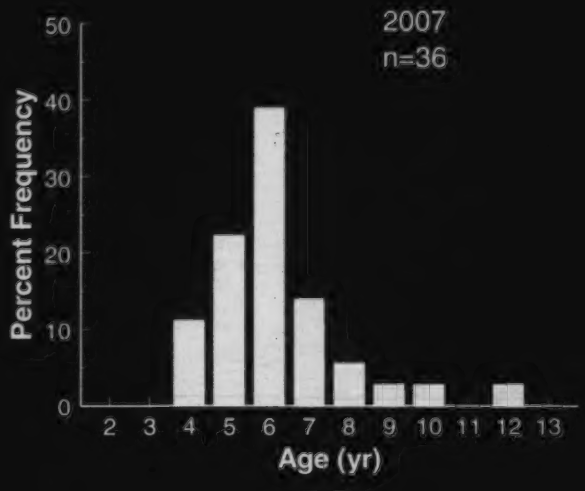

2007
n=36
Percent Frequency
Age (yr)

Fig. 13. Cont'd.

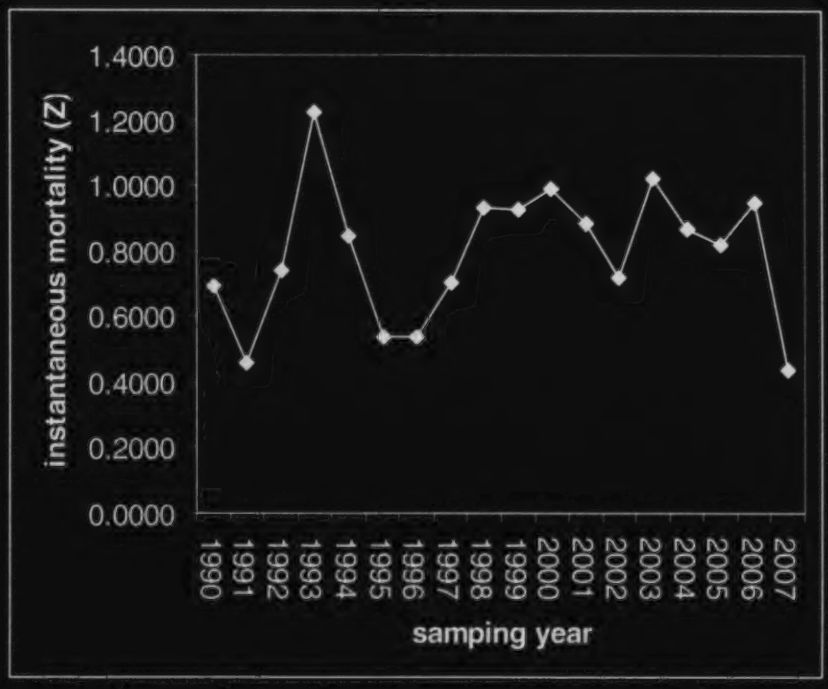


Fig. 14. Instantaneous mortality for the late summer subsistence fishery of Arctic charr at the Hornaday River, 1990-2007.

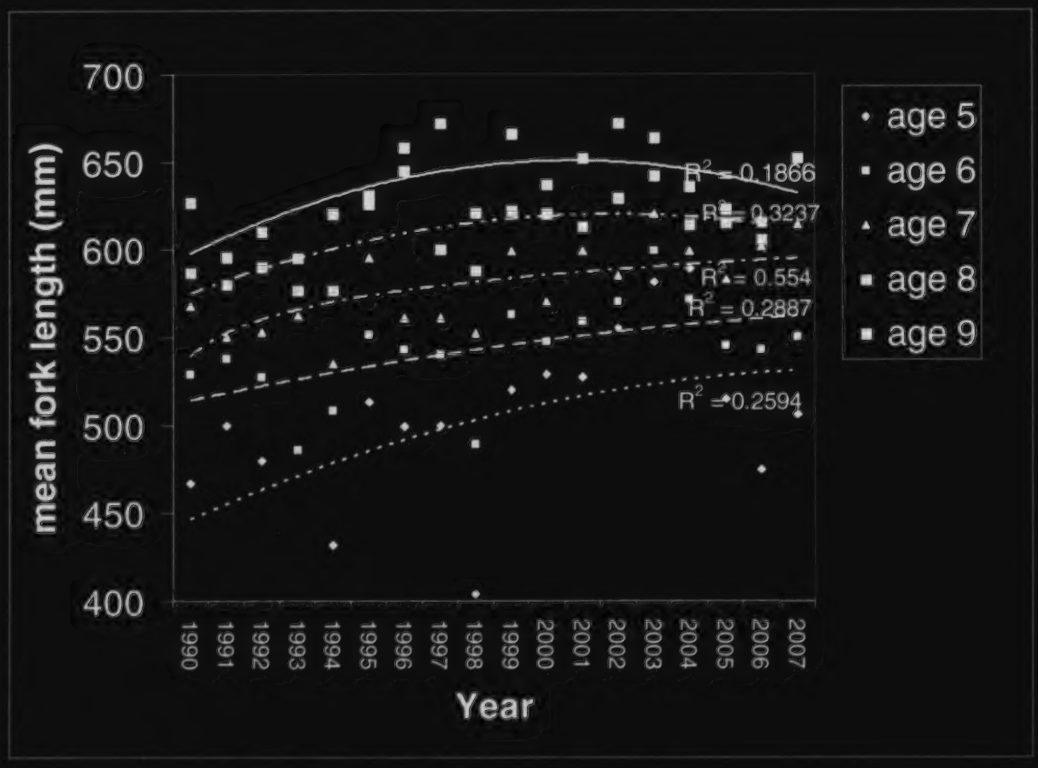


Fig. 15. Mean length-at-age of Hornaday River Arctic charr aged 5-9 y, 1990-2007.

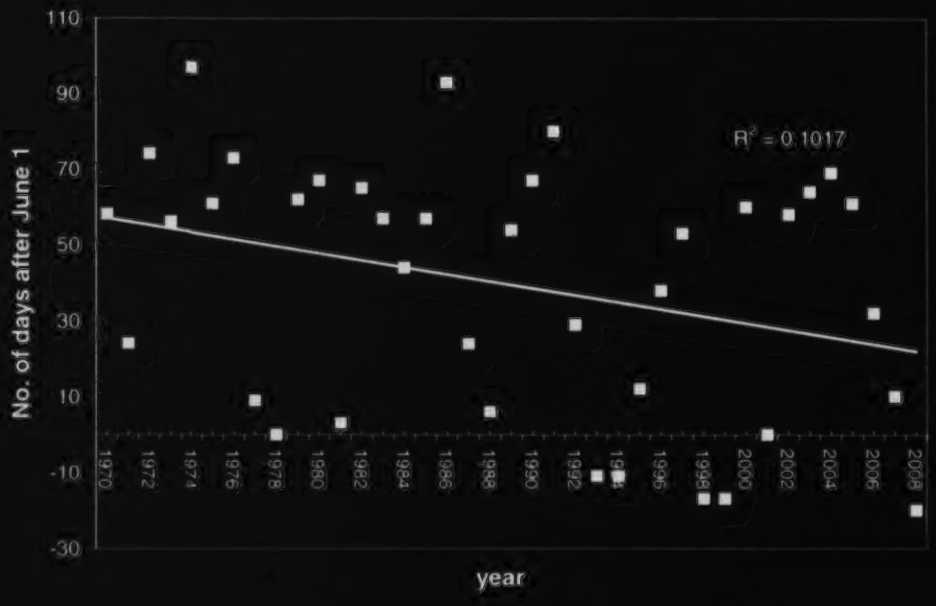


Fig. 16. Date of ice clearing in Amundsen Gulf, 1970-2007 (no. of days after June 1).

Table 1. Mean fork length by mesh size (1990-2007) and mean CPUE by mesh size (1997-2007) for the late summer Arctic charr subsistence fishery at the Hornaday River, NT.

Mesh size		fork length (mm)			CPUE (no. charr/100m/24h)		
mm	in	mean	sd	n	mean	sd	No. of sets
114	4.5	574.04	71.37	1680	24.55	33.5	556
127	5	580.54	69.36	1156	18.4	23.77	36
133	5.25	611.82	56.91	71	17.19	27.53	901
140	5.5	584.46	72.54	418	16.28	37.94	115
166	6	656.5	56.53	6	16.11	28.8	223
total				3331			1831

Table 2. Size, age and sex ratio of Arctic charr harvested from the Hornaday River late summer subsistence fishery, 1990-2007.

sample year	sample sizes				size & condition							age					sex ratio
	no. dead sampled	% harvest	no. aged	len/wt only	mean length		mean weight		prop >600 mm	K mean	K sd	mean	sd	min	max	mode	
	n	dead sampled	n	n	mm	sd	g	sd				y		y	y	y	% male
1990	192	11.62	169	787	567.3	80.0	2202.0	942.9	0.26	1.23	0.20	7.25	1.64	2	12	7	45
1991	260	19.35	238	722	565.9	66.3	2059.0	826.9	0.16	1.21	0.14	7.26	1.55	4	11	6	54
1992	219	19.59	197	721	562.6	58.4	2278.0	756.7	0.22	1.27	0.13	7.29	1.27	5	12	7	58
1993	219	17.79	322	571	567.6	61.5	2453.0	721.5	0.29	1.28	0.18	7.90	1.16	4	13	8	51
1994	214	23.78	247	176	577.1	75.3	2481.0	882.1	0.36	1.25	0.21	7.90	1.43	4	13	8	46
1995	299	13.76	261	640	584.1	75.0	2391.0	933.9	0.35	1.26	0.13	7.05	1.64	3	11	9	44
1996	188	14.62	179	347	556.5	78.3	2287.0	990.0	0.27	1.20	0.16	6.56	1.75	4	13	6	55
1997	205	15.64	184	326	554.2	64.3	1969.0	780.7	0.18	1.15	0.13	6.53	1.17	4	10	6	49
1998	183	15.12	171	0	552.5	78.4	2419.0	934.2	0.24	1.37	0.19	7.25	1.17	5	12	7	53
1999	159	18.34	151	0	568.7	72.9	2661.0	1033.0	0.31	1.37	0.24	6.40	1.31	2	11	6	53
2000	291	32.41	285	0	568.7	71.5	2497.0	1069.2	0.33	1.28	0.18	6.72	1.07	4	11	6	61
2001	275	32.31	269	0	576.3	64.3	2627.0	884.8	0.32	1.33	0.18	6.54	1.07	4	10	6	63
2002	198	26.29	195	363	598.7	63.9	2363.0	777.9	0.36	1.17	0.14	7.22	1.25	5	13	7	53
2003	534	57.48	178	0	611.0	56.4	2502.0	796.1	0.41	1.19	0.18	7.60	0.98	4	11	8	52
2004	240	24.00	238	89	610.9	57.5	2720.0	718.1	0.55	1.18	0.23	7.78	1.16	5	13	8	64
2005	107	30.75	105	96	597.3	50.8	2560.0	643.3	0.46	1.17	0.15	7.81	1.21	5	11	7	51
2006	55	45.45	53	63	596.8	66.9	2881.0	884.4	0.53	1.27	0.24	7.85	1.39	5	11	8	38
2007	50	23.92	36	8	551.1	64.6	1969.0	668.4	0.19	1.19	0.13	6.17	1.66	4	12	6	63

Table 3. Instantaneous mortality rates (Z), annual survival rate (S) and Annual Mortality Rate (A) for the Hornaday River charr subsistence fishery, 1990-2007.

Year	Intercept	SLOPE	Z	S	A	ages used
1990	9.16	-0.69315	0.6932	0.5000	0.5000	7-11
1991	7.21	-0.45554	0.4555	0.6341	0.3659	6-11
1992	9.50	-0.73889	0.7389	0.4777	0.5224	7-11
1993	14.88	-1.22593	1.2259	0.2935	0.7065	8-11
1994	11.26	-0.84894	0.8489	0.4279	0.5721	8-13
1995	7.66	-0.53788	0.5379	0.5840	0.4160	6-12
1996	7.17	-0.53845	0.5385	0.5837	0.4163	6-13
1997	8.61	-0.70524	0.7052	0.4940	0.5060	6-10
1998	10.89	-0.93163	0.9316	0.3939	0.6061	7-12
1999	9.94	-0.92868	0.9287	0.3951	0.6049	6-11
2000	11.17	-0.99122	0.9912	0.3711	0.6289	6-10
2001	10.26	-0.88344	0.8834	0.4134	0.5866	6-10
2002	9.02	-0.71662	0.7166	0.4884	0.5116	7-14
2003	11.83	-1.02149	1.0215	0.3601	0.6399	7-11
2004	11.06	-0.86779	0.8678	0.4199	0.5801	8-13
2005	9.80	-0.81967	0.8197	0.4406	0.5594	7-11
2006	10.70	-0.94964	0.9496	0.3869	0.6131	8-11
2007	4.61	-0.43637	0.4364	0.6464	0.3536	6-12